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SHIFTING GUSTATORY THRESHOLDS AND FOOD CRAVINGS DURING PREGNANCY AS EXPANDING UTERINE-INDUCED STEADY POTENTIAL SHIFTS WITHIN THE INSULA: AN HYPOTHESIS [1]

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Summary.—A logical extrapolation from the principle that structure dictates function is that transient or anomalous experiences are consequences of simultaneous stimulations of proximal brain regions not typically co-activated. In this paper the occasional shifts in gustatory threshold during the menstrual cycle, the craving for unusual tastes experienced by some during pregnancies, and, the reports by postmenopausal women of the "burning mouth syndrome" are hypothesized to be artifacts of the proximity of gustatory and uterine representations within the female insula. Transient (menstrual) or tonic (pregnancy) stimulation within the uterus might shift the locus of neuronal activity within the insula to include adjacent gustatory neurons and consequently alter taste experiences. Specific tests of this hypothesis are suggested.

The human body can be viewed topologically as a Klein Bottle. The somatotopic representation of the peripheral body surface, the classic "homunculus," is contained within the parietal cortices. Topological extensions of the body's surface invaginate through the oral cavity as the epithelium of the oesophagus, alimentary canal, stomach, intestines, and colon. Their representations extend within the parietal operculum and continue into the insula (1). The distal end of this internal representation emerges as the anus and is contiguous with the adjacent peripheral body surface.

The conspicuous sexual dimorphism of the organs within the lower abdomen would predict sex-specific phenomena because representations of the uterus and the inner vagina would be continuations of this visceral manifold within the insular cortex. The rapid growth of epithelial cells within the endometrium between ovulation and menstruation as well as the gradually progressive stretching of the uterine muscles to accommodate a growing fetus would elevate the phasic and tonic activity, respectively, within the insular complex that represents this specific female pelvic organ. Afferents from the uterus and likely the ovaries are mediated by the vagal and splanchnic nerves that carry ascending viscerosensory information into the posterior orbital gyrus and its insular continuation (4).

The functional gustatory cortices, which are associated with the awareness of taste in general and specific classes of gustatory experiences in particular, clearly involve the insular cortices as well as the proximal cerebral cortices within the parietal and frontal opercula (7). Positron Emission Tomography has shown bilateral activation of the insula, the temporal pole, and the orbitofrontal cortices for tastes that involve strong olfactory components (2).

Periodic changes in uterine chemistry, such as during the premenstrual interval, would be expected to alter neuroelectrical activity of neurons within the insula and to alter gustatory

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thresholds. Stimulation of the ventral insular region has been known to induce taste experiences, and the removal of the ventral insula has been reported to raise the threshold for gustatory detection (7). Because the shift in taste sensitivity and preferences (which reflect the reward-related or affect component of taste) often involve the dimension of sweetness, the location of these discrete regions within the right or left hemisphere might be inferred.

During more gradual, protracted increases in the distention of uterine muscles such as during pregnancy, alterations in the *qualitative* characteristics of taste might occur because fields of gustatory neurons (not typically co-activated) within regions of the insula most adjacent to the uterine representations could be affected by expanding shifts in the steady potentials evoked by the tonic uterine stimulation. If this hypothesis be valid, then the portion of the pregnancy associated with greatest relative increase in uterine muscle distention and hence tonic input to the insular representation (usually before the transition of the first to second trimester), should be associated with most frequent incidences of transient "odd tastes" that require accommodation by specific substances.

If specific, familiar gustatory experiences are determined by the pattern of neural responses evoked by specific foods, then persistent alterations in background inhibitory insular activity would alter this context and also change the experiential correlates of an otherwise routine lingual stimulus. Unusual combinations of tastes ("pickles and ice cream") could generate palatable and pleasant gustatory experiences given this change in context within the tonically activated insular neurons. Not all pregnant women would be expected to report dysgeusia. If this hypothesis be correct, then women with the smaller uteruses whose distention and hence insular activation would be above average should be most susceptible. Similarly, women who exhibit greater intercalation between the two hemispheres, such as left-handed persons, would be more likely to label verbally and to become aware of these specific tastes.

Although changes in emotionality during both premenstrual states and pregnancy would be expected given the significant afferent connections from this region of the insula to the anterior pole of the temporal lobe and the basolateral group of the amygdala, enhanced "meaningfulness" of the reward value for the novel taste would be expected. This affect might be discerned by shifts in the ratings of the personal (psychological) importance of specific foods. In addition to the hedonistic component of these tastes, there should also be a correlative feeling of vague, comforting "familiarity," a frequent correlate of amygdaloid activation. Considering the input from the nucleus accumbens, one would also expect that the "cravings" for specific foods would be subjectively similar to the experiences of addiction and withdrawal symptoms when the taste is not available.

There should be ontogenetic consequences of the spatial proximity between representations of taste and of the uterus within the insular region. Menopause would be expected to dampen the periodic sensitization to specific (sweet) tastes due to the attenuation of both the periodicity and concentration of oestrogen available to their receptors within the insula. One possible example of this change is the Burning Mouth Syndrome which is a pain disorder that is primarily reported by postmenopausal women. Also, compared with thresholds for salt, sour, or bitter, patients diagnosed with this syndrome (3) exhibited significantly higher thresholds for sweet tastes than did an age-matched reference group who did not display this syndrome.

A final prediction is that during those periods of the menstrual cycle most associated with alterations in uterine tone or that period of pregnancy associated with the maximum uterine tone before the slow adjustment within this musculature occurs, hallucinatory or illusory gustatory and oral sensations would be most frequent. These experiences would be more frequent in normal women who display elevated temporal lobe sensitivity (6) and episodes of subjective pseudocyesis (5) because activated fibers within the temporal stem pass proximal to the insula. The form of these sensations and their attribution would be strongly affected by situational context and the belief system of the person. For example, one of this researcher's patients was

convinced that someone (whom she could not see) was coercing her to taste materials during twilight states before sleep and before awakening. She also realized, however, that the days in which the "tastes" occurred were also associated with the more intense uterine "sensations."

If slow tonic changes within the pelvic viscera of females affect the general threshold of neurons within the insula that affect taste preferences, then shifts in the preference for *combinations* of different specific tastes should change following impregnation. If this hypothesis be valid, then female rats should display significant shifts in the ratios of the consumptions of fluids with different tastes during the three weeks following conception.

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